

Additional Plots for arXiv:1112.1095

“Mixing It Up With M_{T2} :
Unbiased Mass Measurements
at Hadron Colliders”

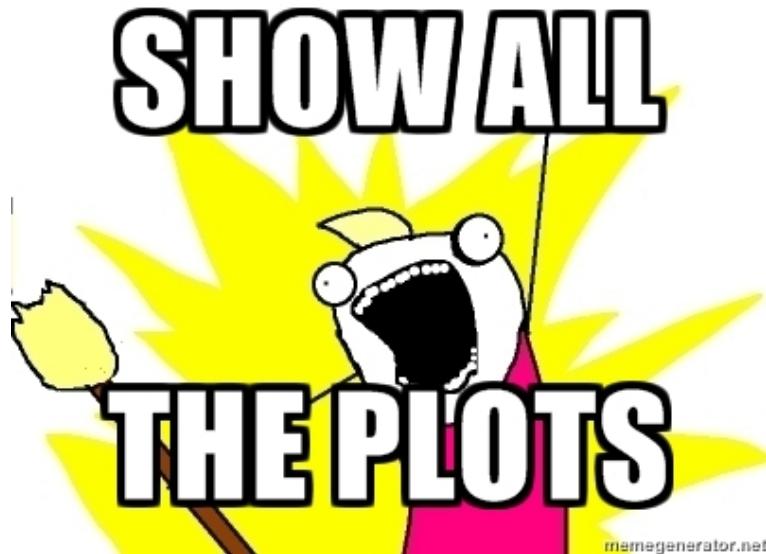
David Curtin

Department of Physics, YITP, Stony Brook University, Stony Brook, NY 11794.

Department of Physics, LEPP, Cornell University, Ithaca, NY 14853.

curtin@insti.physics.sunysb.edu

Abstract



1 First Monte Carlo Study

Note we ignore an edge that is a Filter Artifact at the beginning of the $M_{T2}^{221}(0)$ KE-distribution.

Variable	Prediction	Measurement	Deviation/ σ	Quality
M_{bb}	382.3	391.8 ± 10.3	+0.93	—
$M_{T2\perp}^{221}(0)$	303.5	240 ± 140	-0.45	C
$M_{T2}^{221}(0)$		301 ± 47	-0.05	A
$M_{T2\perp}^{221}(E_b)$	7153.4	7154 ± 42	+0.01	A
$M_{T2}^{221}(E_b)$		7171 ± 42	+0.42	A
$M_{T2\perp}^{210}(0)$	320.9	283 ± 44	-0.86	A
$M_{T2}^{210}(0)$		327.2 ± 8.7	+0.72	A
$M_{T2\perp}^{210}(E_b)$	7239.8	7141 ± 54	-1.84	A
$M_{T2}^{210}(E_b)$		7176 ± 37	-1.75	A
$M_{T2\perp}^{220}(0)$	506.7	509 ± 211	+0.01	C
$M_{T2}^{220}(0)$		528 ± 56	+0.38	B
$M_{T2\perp}^{220}(E_b)$	7393.1	7484 ± 106	+0.86	B
$M_{T2}^{220}(E_b)$		7456 ± 70	+0.90	B
$M_{T2\perp\text{all}}^{210}(0)$	312.8	249 ± 52	-1.23	B
$M_{T2\perp\text{all}}^{210}(E_b)$	7158.2	7129 ± 40	-0.73	A

Table 1: Edge Measurements for the first Monte Carlo Study. $E_b = 7000$ GeV. The measurements are obtained from the 1σ confidence level intervals.

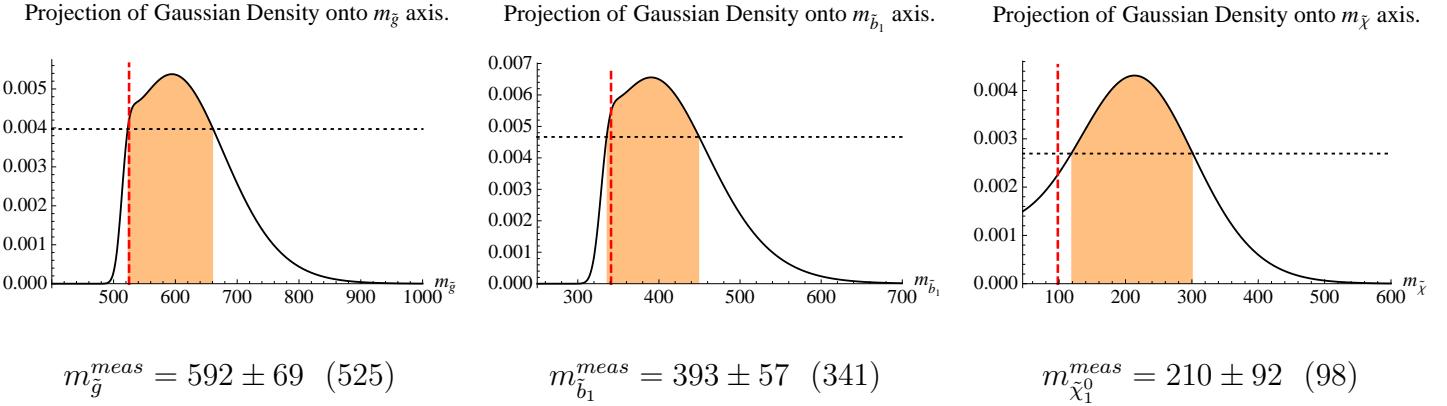


Figure 1: Mass measurements for the first Monte Carlo Study in GeV (actual masses in brackets). The plots show the gaussian density projections for the three masses. The $1-\sigma$ confidence level interval is shaded, and the true mass value is indicated with the vertical dashed line. The dotted line indicates the value of D_{\min} which defines the confidence interval.

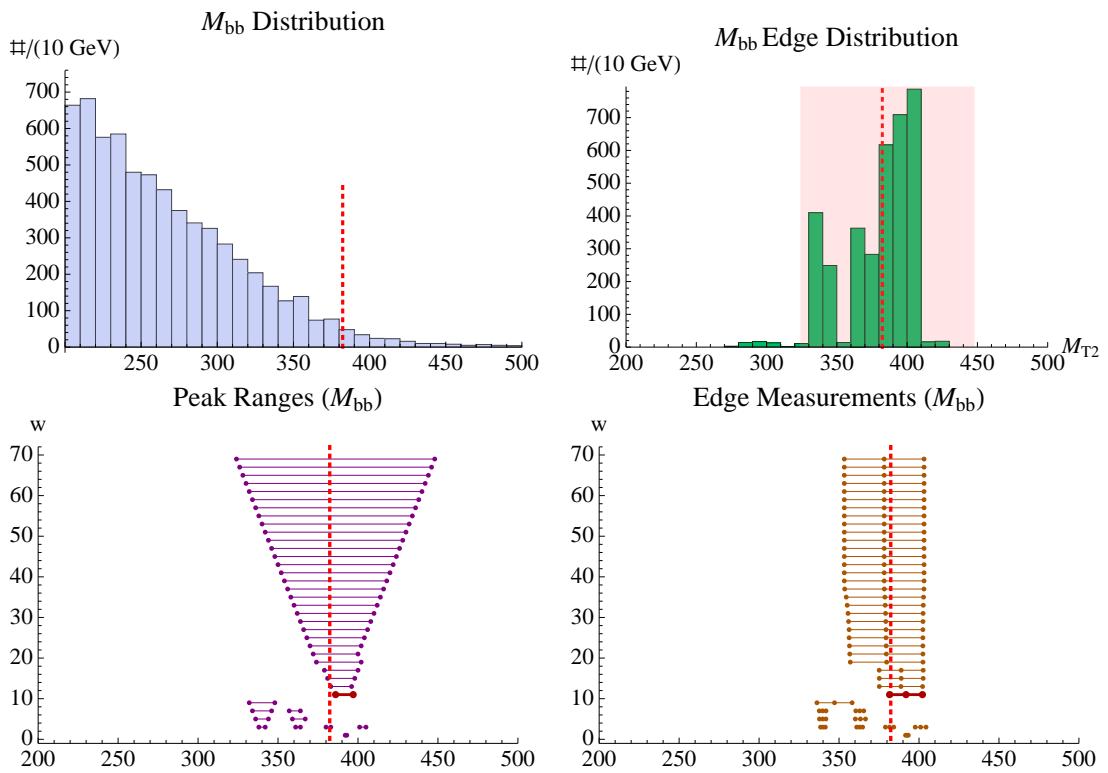


Figure 2: M_{bb}^{max} measurements for first Monte Carlo Study.

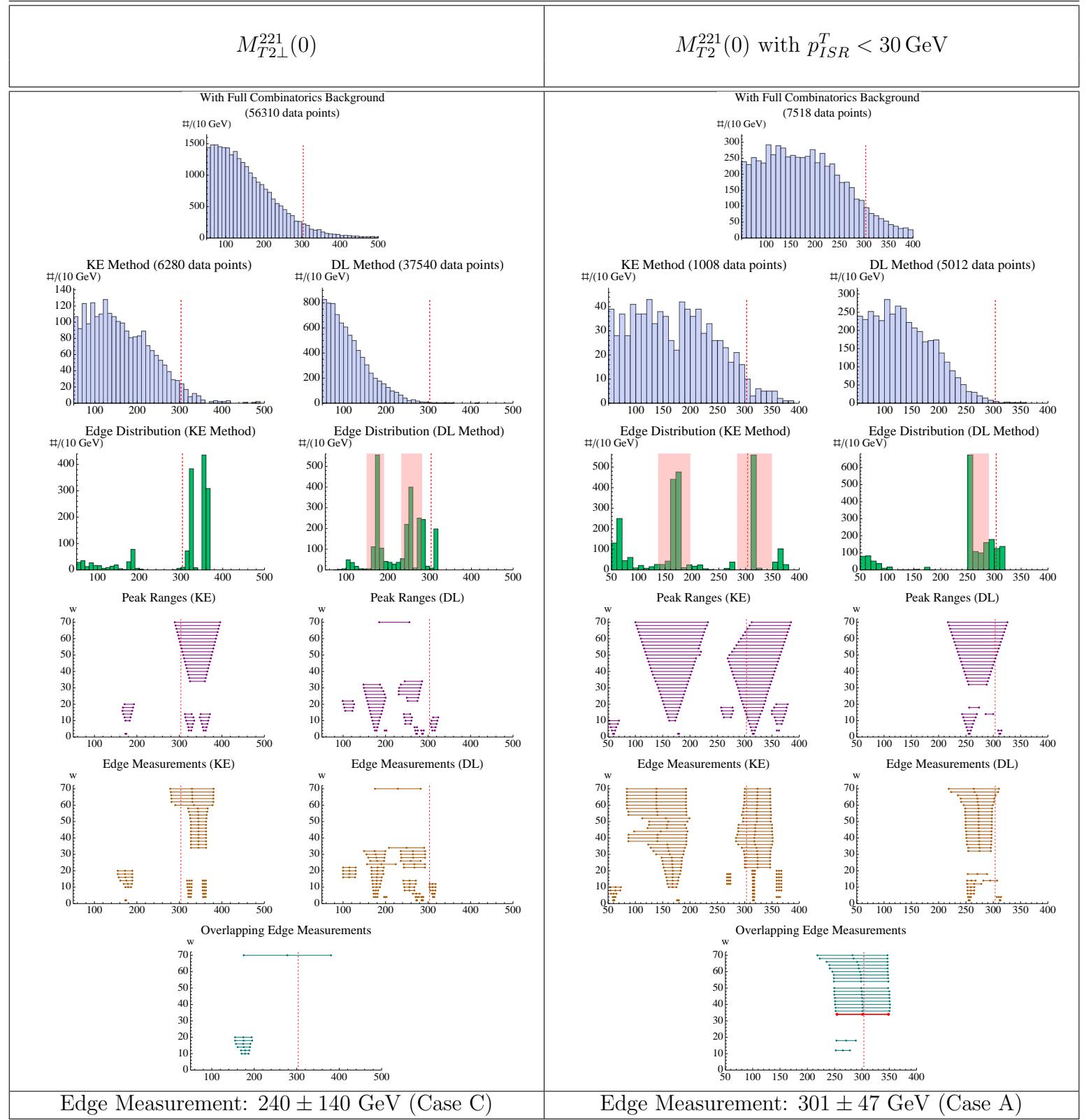
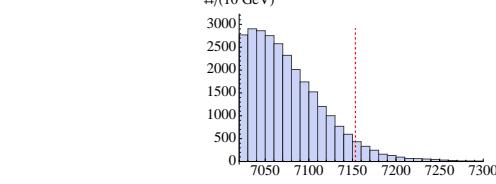


Figure 3: $M_{T2}^{221}(0)$ (First Monte Carlo Study). Prediction: $M_{T2}^{max} = 303.5$ GeV.

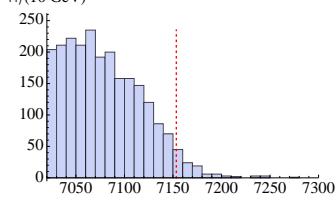
$M_{T2\perp}^{221}(E_b)$

$M_{T2}^{221}(E_b)$ with $p_{ISR}^T < 45 \text{ GeV}$

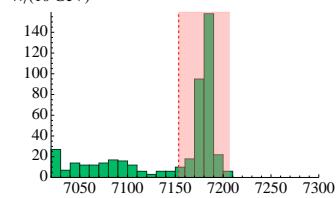
With Full Combinatorics Background
(56310 data points)



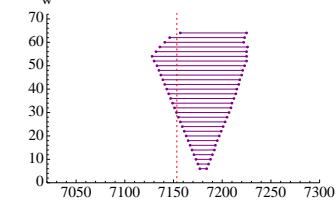
KE Method (6280 data points)



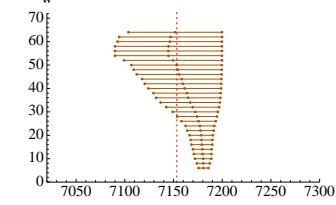
Edge Distribution (KE Method)



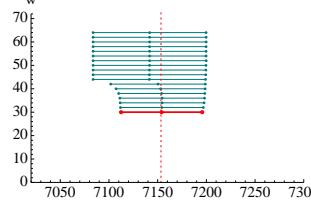
Peak Ranges (KE)



Edge Measurements (KE)

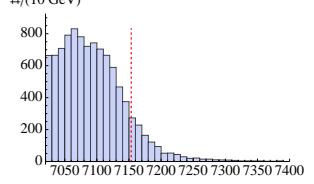


Overlapping Edge Measurements

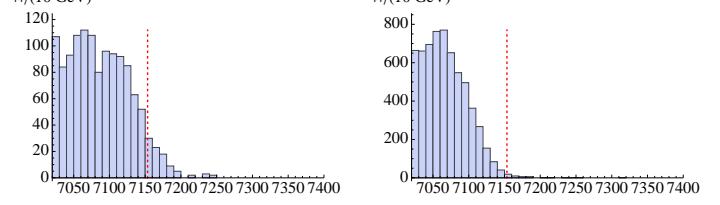


Edge Measurement: $7154 \pm 42 \text{ GeV}$ (Case A)

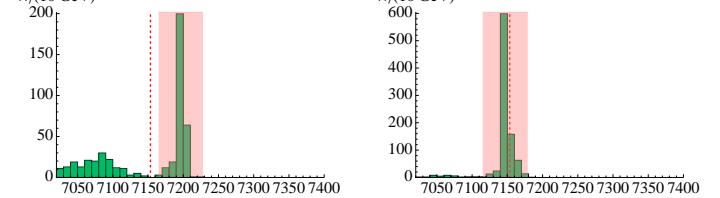
With Full Combinatorics Background
(11088 data points)



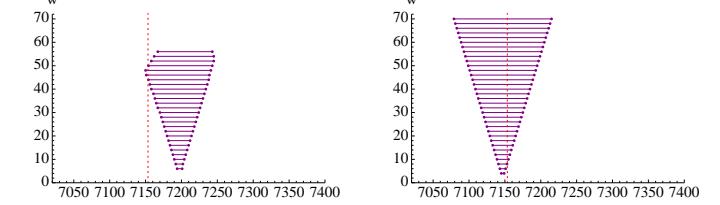
KE Method (1444 data points)



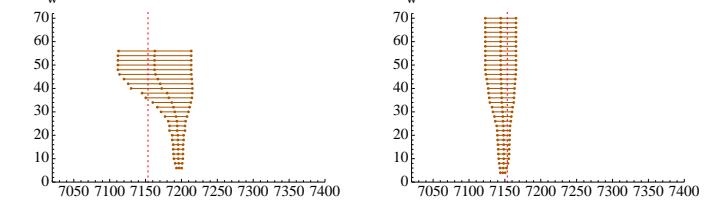
Edge Distribution (KE Method)



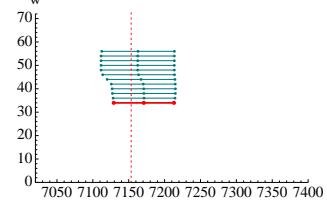
Peak Ranges (KE)



Edge Measurements (KE)



Overlapping Edge Measurements



Edge Measurement: $7171 \pm 42 \text{ GeV}$ (Case A)

Figure 4: $M_{T2}^{221}(E_b)$ (First Monte Carlo Study). Prediction: $M_{T2}^{max} = 7153.4 \text{ GeV}$.

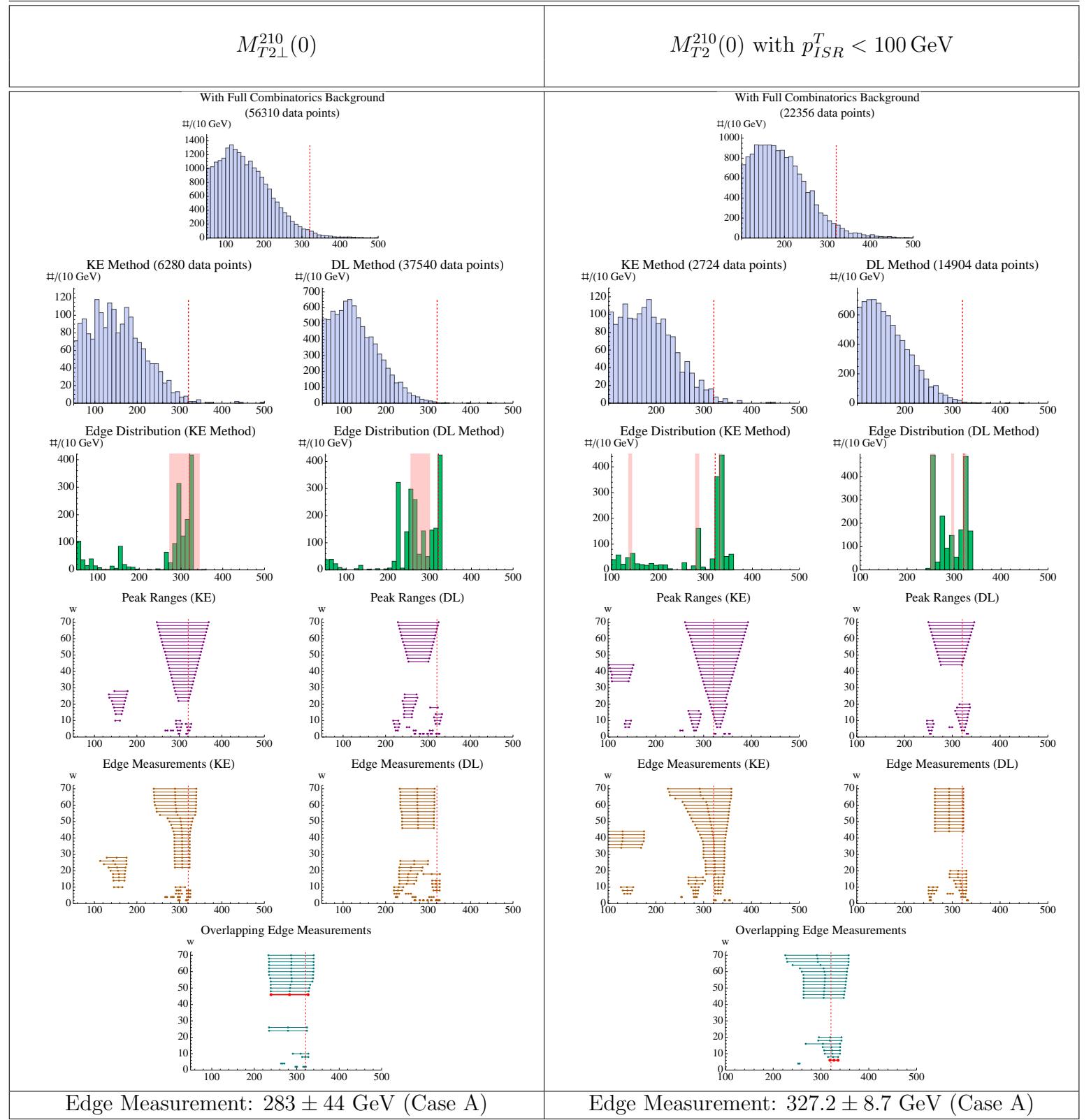
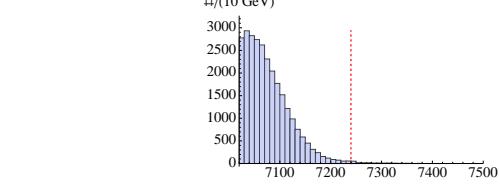


Figure 5: $M_{T2}^{210}(0)$ (First Monte Carlo Study). Prediction: $M_{T2}^{max} = 320.9$ GeV.

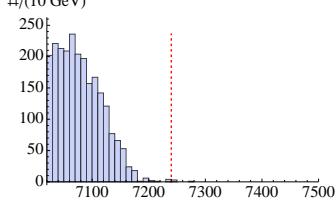
$M_{T2\perp}^{210}(E_b)$

$M_{T2}^{210}(E_b)$ with $p_{ISR}^T < 50 \text{ GeV}$

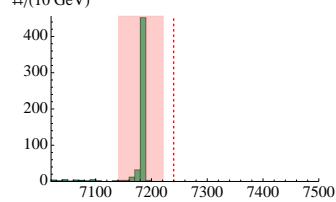
With Full Combinatorics Background
(56310 data points)



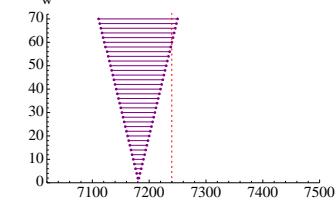
KE Method (6280 data points)



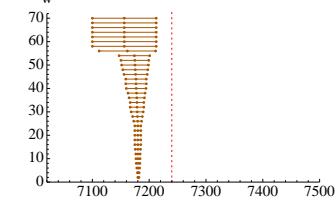
Edge Distribution (KE Method)



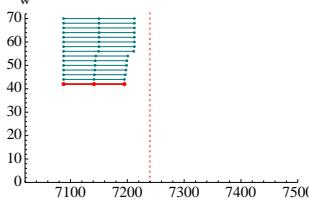
Peak Ranges (KE)



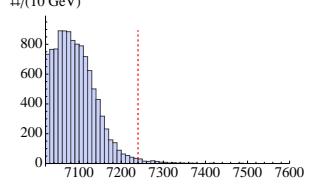
Edge Measurements (KE)



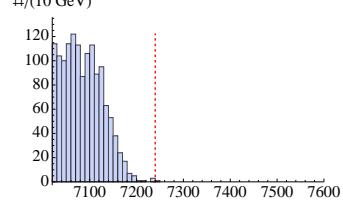
Overlapping Edge Measurements



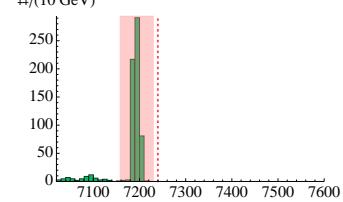
With Full Combinatorics Background
(12192 data points)



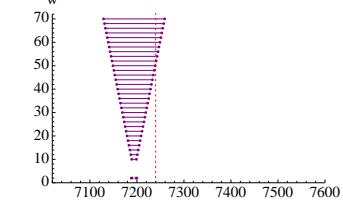
KE Method (1560 data points)



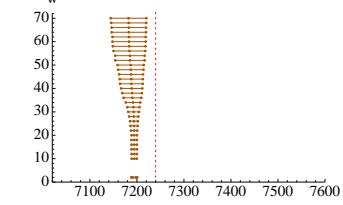
Edge Distribution (KE Method)



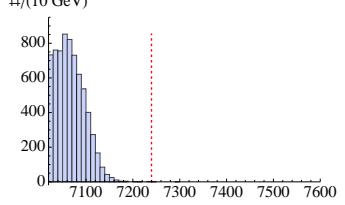
Peak Ranges (KE)



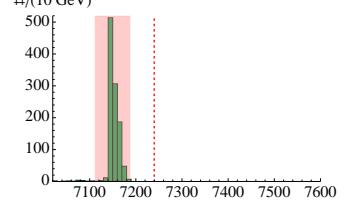
Edge Measurements (KE)



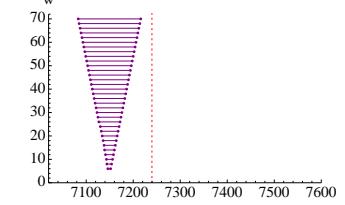
DL Method (8128 data points)



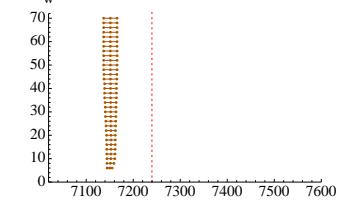
Edge Distribution (DL Method)



Peak Ranges (DL)



Edge Measurements (DL)



Edge Measurement: $7141 \pm 54 \text{ GeV}$ (Case A)

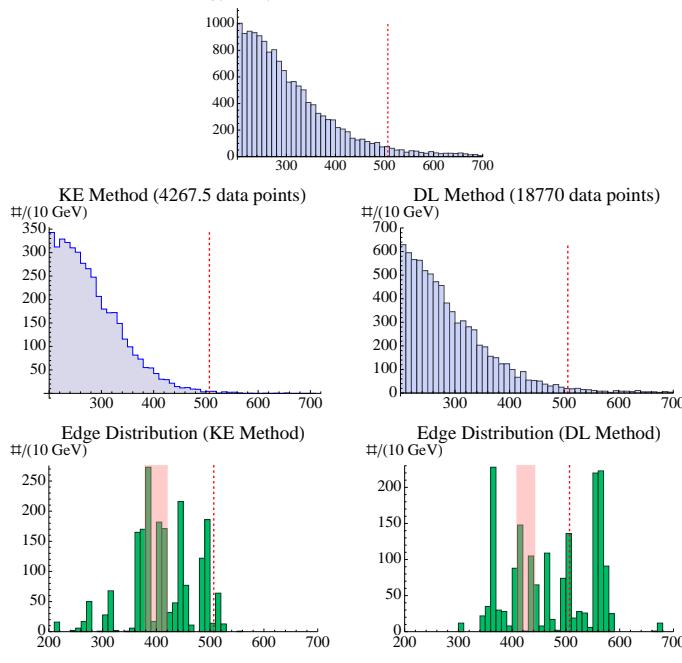
Edge Measurement: $7176 \pm 37 \text{ GeV}$ (Case A)

Figure 6: $M_{T2}^{210}(E_b)$ (First Monte Carlo Study). Prediction: $M_{T2}^{max} = 7239.8 \text{ GeV}$.

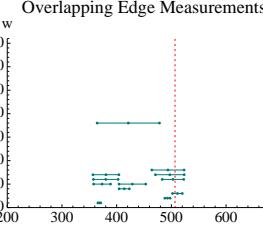
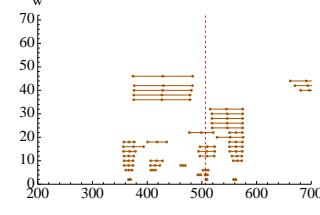
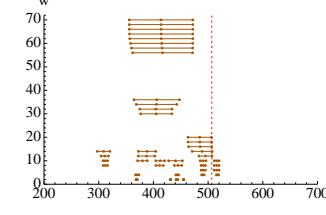
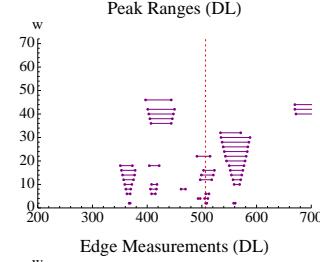
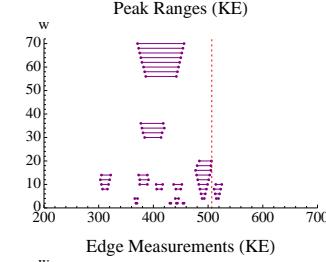
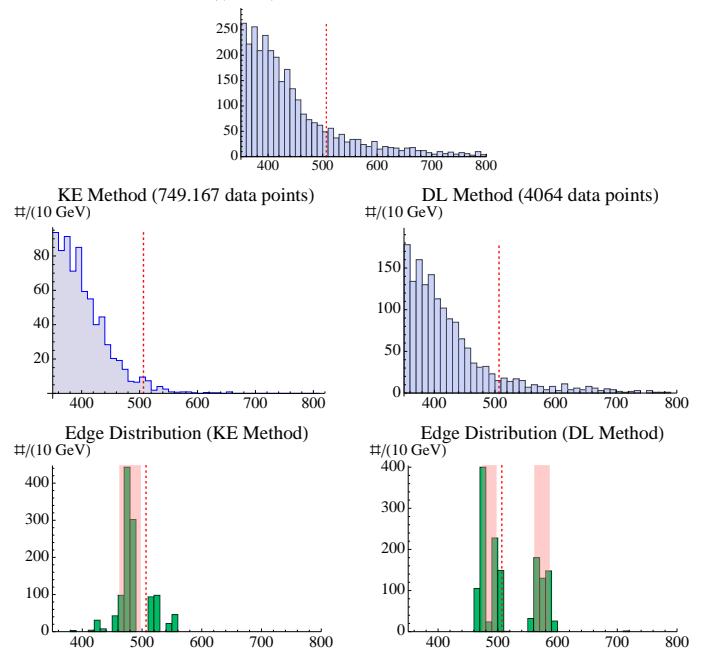
$M_{T2\perp}^{220}(0)$

$M_{T2}^{220}(0)$ with $p_{ISR}^T < 50 \text{ GeV}$

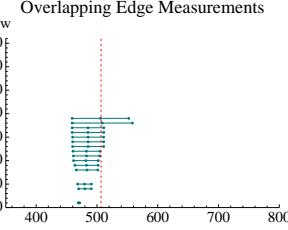
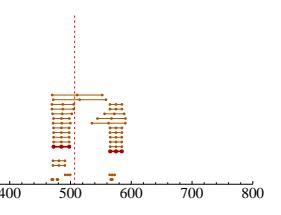
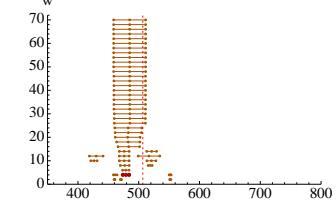
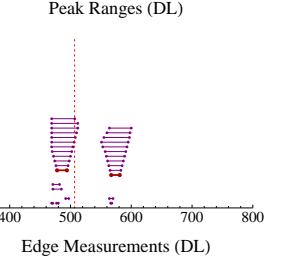
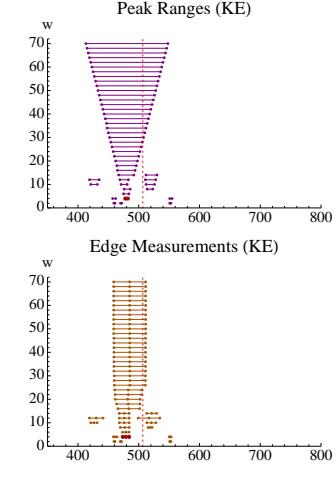
With Full Combinatorics Background
(28155 data points)



With Full Combinatorics Background
(6096 data points)



Edge Measurement: $509 \pm 211 \text{ GeV}$ (Case C)



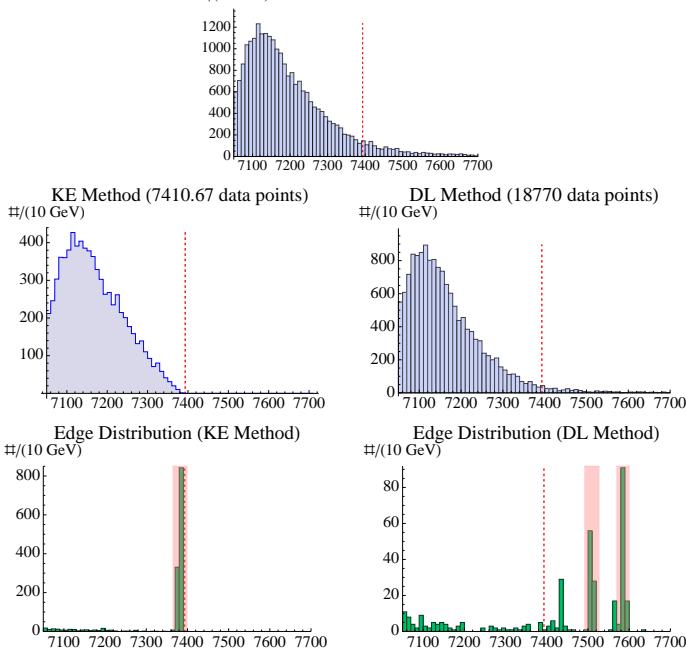
Edge Measurement: $528 \pm 56 \text{ GeV}$ (Case B)

Figure 7: $M_{T2}^{220}(0)$ (First Monte Carlo Study). Prediction: $M_{T2}^{max} = 506.7 \text{ GeV}$.

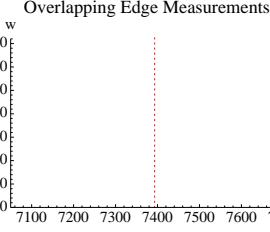
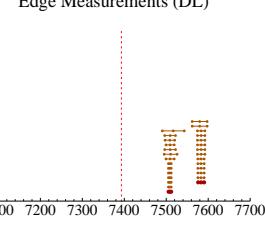
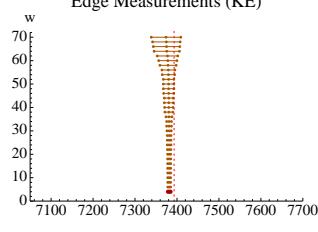
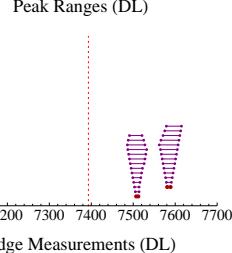
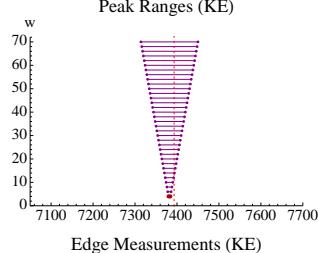
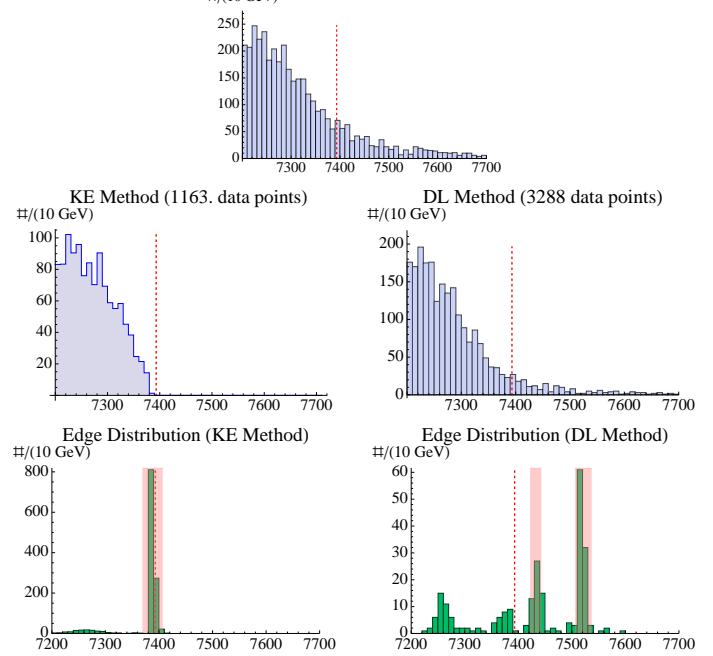
$M_{T2\perp}^{220}(E_b)$

$M_{T2}^{220}(E_b)$ with $p_{ISR}^T < 40 \text{ GeV}$

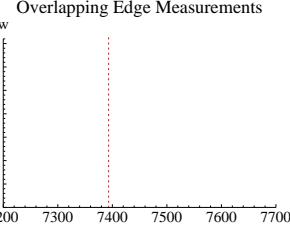
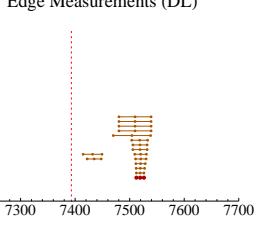
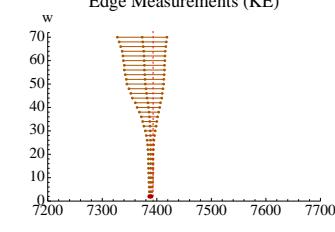
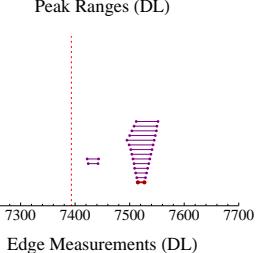
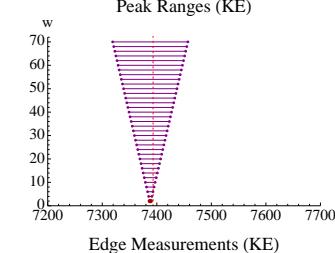
With Full Combinatorics Background
(28155 data points)



With Full Combinatorics Background
(4932 data points)



Edge Measurement: $7484 \pm 106 \text{ GeV}$ (Case B)



Edge Measurement: $7456 \pm 70 \text{ GeV}$ (Case B)

Figure 8: $M_{T2}^{220}(E_b)$ (First Monte Carlo Study). Prediction: $M_{T2}^{max} = 7393.1 \text{ GeV}$.

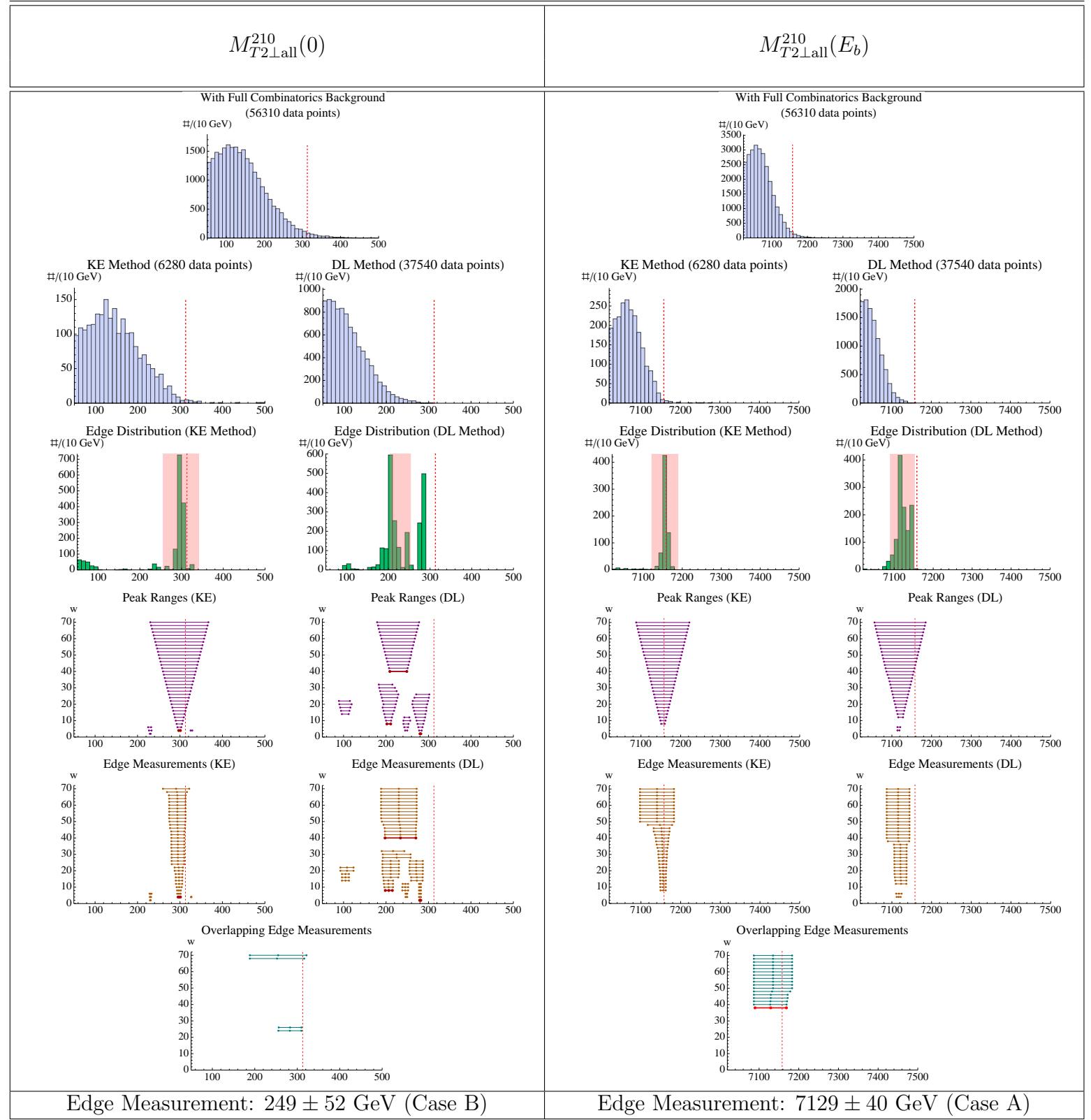


Figure 9: $M_{T2 \perp \text{all}}^{210}(0)$ and $M_{T2 \perp \text{all}}^{210}(E_b)$ (First Monte Carlo Study). Predictions: $M_{T2}^{\max} = 312.8$ GeV and 7158.2 GeV respectively.

2 Second (Blind) Monte Carlo Study

Note that we ignore some edges that are filter artifacts at the beginning of the $M_{T2\perp}^{221}(0)$, $M_{T2}^{221}(0)$, $M_{T2\perp}^{210}(0)$ and $M_{T2\perp}^{210}(E_b)$ KE-distributions.

Variable	Prediction	Measurement	Deviation/ σ	Quality
M_{bb}	563.4	556.5 ± 14.9	-0.46	—
$M_{T2\perp}^{221}(0)$	472.0	340 ± 148	-0.89	B
$M_{T2}^{221}(0)$		426 ± 83	-0.55	B
$M_{T2\perp}^{221}(E_b)$	7239.5	7218 ± 67	-0.33	A
$M_{T2}^{221}(E_b)$		7239 ± 48	-0.01	A
$M_{T2\perp}^{210}(0)$	391.3	343 ± 83	-0.58	B
$M_{T2}^{210}(0)$		406.8 ± 10.8	+1.43	A
$M_{T2\perp}^{210}(E_b)$	7333.1	7215 ± 71	-1.67	A
$M_{T2}^{210}(E_b)$		N/A		D
$M_{T2\perp}^{220}(0)$	693.0	598 ± 165	-0.57	C
$M_{T2}^{220}(0)$		681 ± 64	-0.19	B
$M_{T2\perp}^{220}(E_b)$	7572.9	7663 ± 125	+0.73	B
$M_{T2}^{220}(E_b)$		7642 ± 93	+0.74	B
$M_{T2\perp\text{all}}^{210}(0)$	385.5	327 ± 128	-0.45	C
$M_{T2\perp\text{all}}^{210}(E_b)$	7195.4	7184 ± 47	-0.24	A

Table 2: Edge Measurements for the second Monte Carlo Study. $E_b = 7000$ GeV. The measurements are obtained from the 1σ confidence level intervals.

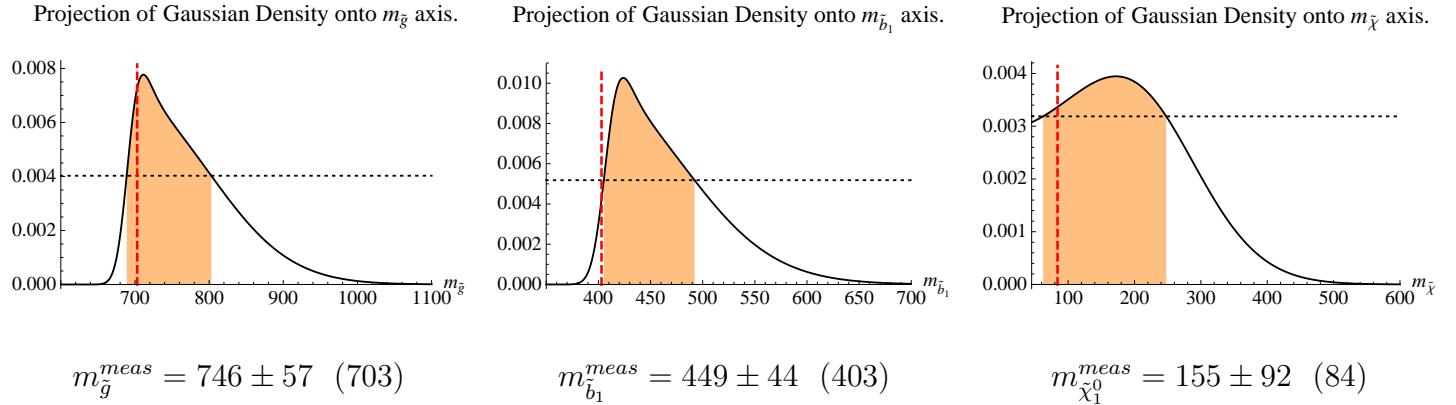


Figure 10: Mass measurements for the second Monte Carlo Study in GeV (actual masses in brackets). The plots show the gaussian density projections for the three masses. The $1-\sigma$ confidence level interval is shaded, and the true mass value is indicated with the vertical dashed line. The dotted line indicates the value of \mathcal{D}_{\min} which defines the confidence interval.

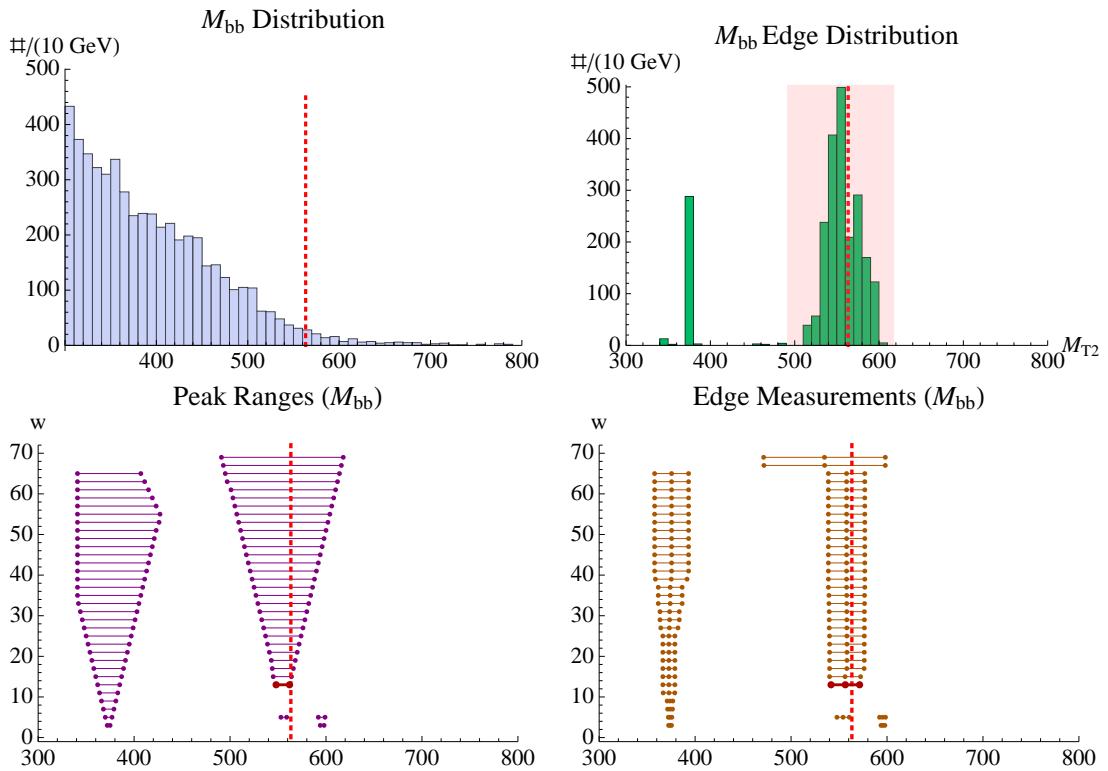


Figure 11: M_{bb}^{max} measurements for second Monte Carlo Study. Note we ignore the peak in the edge distribution at ~ 400 GeV because we know the real edge is at ~ 600 GeV, since that is the feature that prominently shows up in the distribution for many different cuts that reduce combinatorics background.

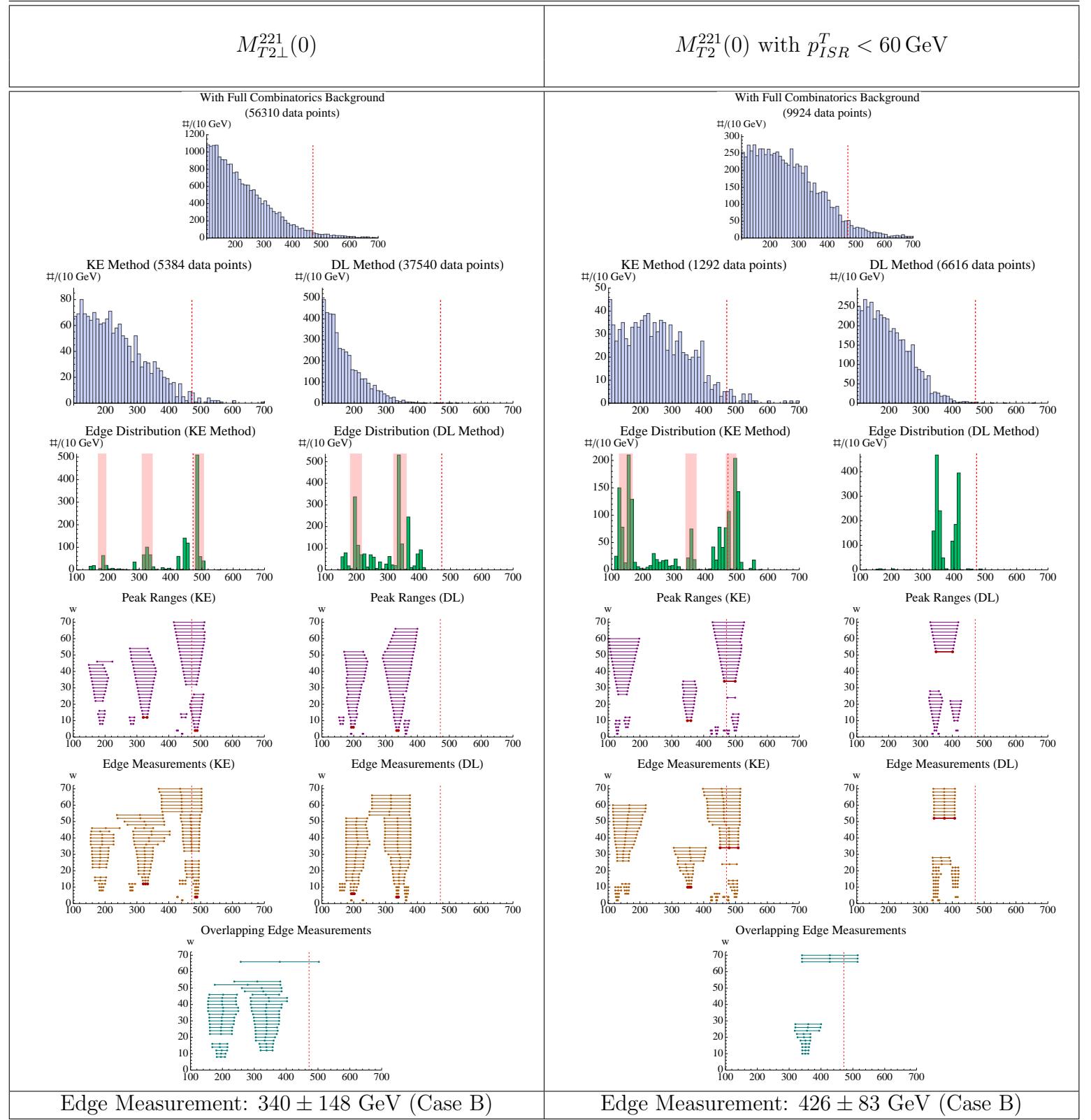
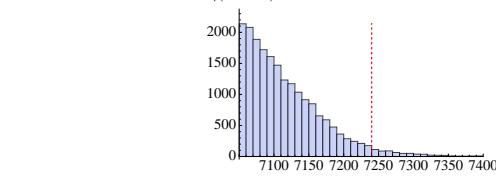


Figure 12: $M_{T2}^{221}(0)$ (Second Monte Carlo Study). Prediction: $M_{T2}^{max} = 472.0$ GeV

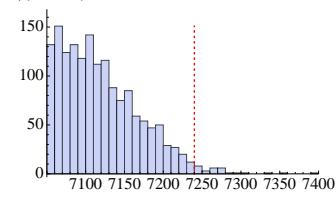
$M_{T2\perp}^{221}(E_b)$

$M_{T2}^{221}(E_b)$ with $p_{ISR}^T < 80 \text{ GeV}$

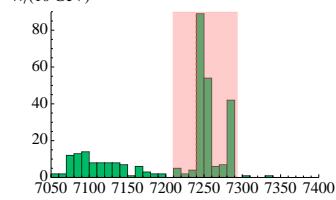
With Full Combinatorics Background
(56310 data points)



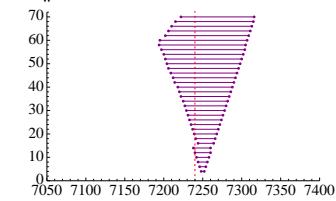
KE Method (5384 data points)



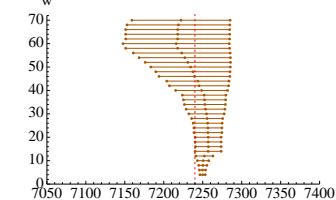
Edge Distribution (KE Method)



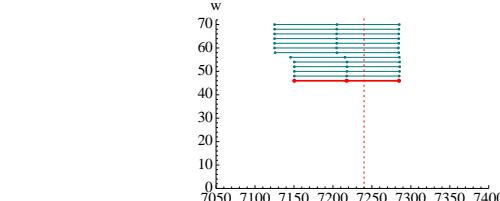
Peak Ranges (KE)



Edge Measurements (KE)

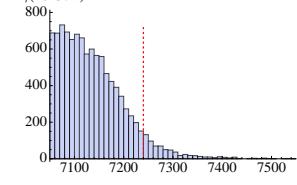


Overlapping Edge Measurements

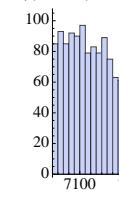


Edge Measurement: $7218 \pm 67 \text{ GeV}$ (Case A)

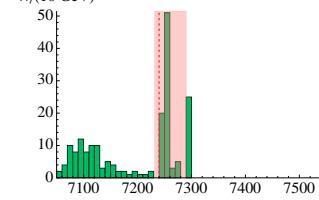
With Full Combinatorics Background
(13290 data points)



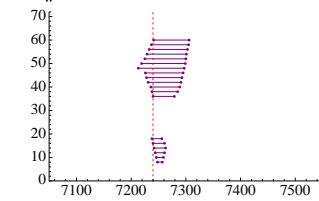
KE Method (1720 data points)



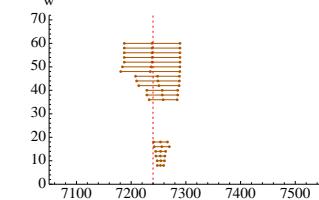
Edge Distribution (KE Method)



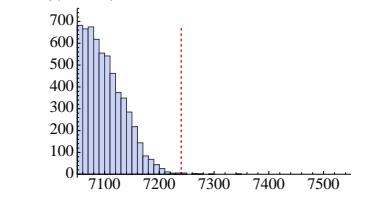
Peak Ranges (KE)



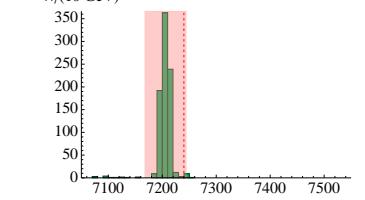
Edge Measurements (KE)



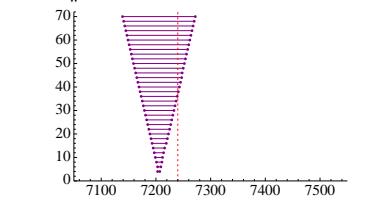
DL Method (8860 data points)



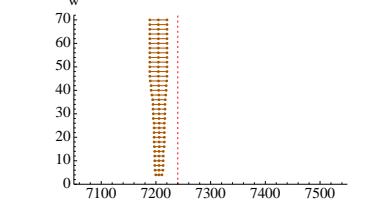
Edge Distribution (DL Method)



Peak Ranges (DL)



Edge Measurements (DL)



Overlapping Edge Measurements



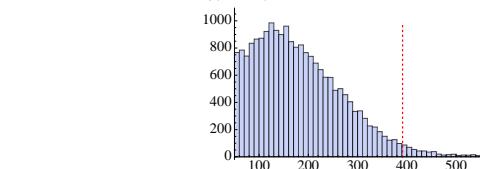
Edge Measurement: $7239 \pm 48 \text{ GeV}$ (Case A)

Figure 13: $M_{T2}^{221}(E_b)$ (Second Monte Carlo Study). Prediction: $M_{T2}^{max} = 7239.5 \text{ GeV}$

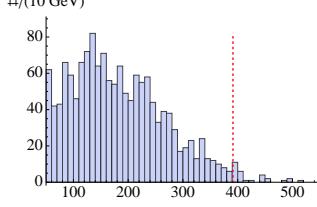
$M_{T2\perp}^{210}(0)$

$M_{T2}^{210}(0)$ with $p_{ISR}^T < 100 \text{ GeV}$

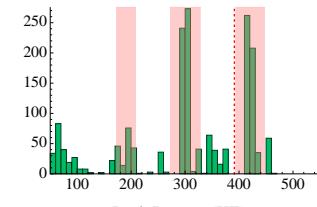
With Full Combinatorics Background
(56310 data points)



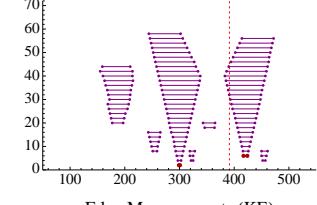
KE Method (5384 data points)



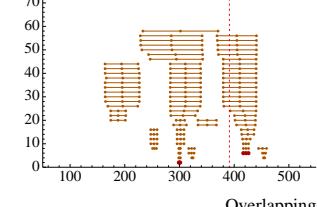
Edge Distribution (KE Method)



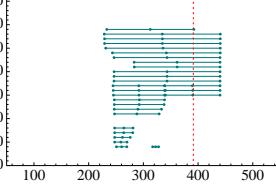
Peak Ranges (KE)



Edge Measurements (KE)

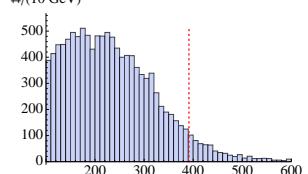


Overlapping Edge Measurements

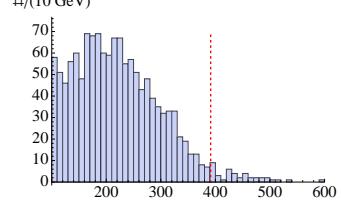


Edge Measurement: $343 \pm 83 \text{ GeV}$ (Case B)

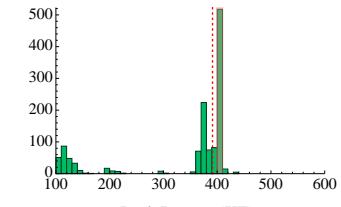
With Full Combinatorics Background
(16338 data points)



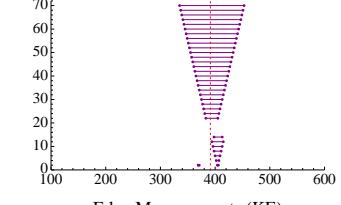
KE Method (2056 data points)



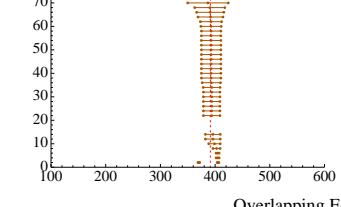
Edge Distribution (KE Method)



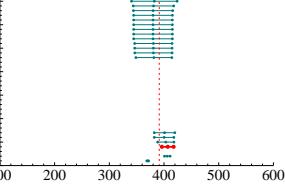
Peak Ranges (KE)



Edge Measurements (KE)



Overlapping Edge Measurements



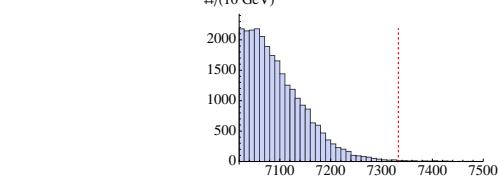
Edge Measurement: $406.8 \pm 10.8 \text{ GeV}$ (Case A)

Figure 14: $M_{T2}^{210}(0)$ (Second Monte Carlo Study). Prediction: $M_{T2}^{max} = 391.3 \text{ GeV}$

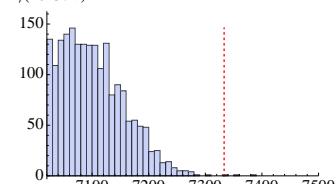
$M_{T2\perp}^{210}(E_b)$

$M_{T2}^{210}(E_b)$ with $p_{ISR}^T < 50 \text{ GeV}$

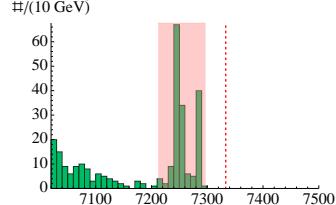
With Full Combinatorics Background
(56310 data points)



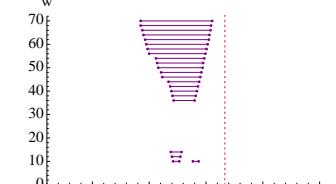
KE Method (5384 data points)



Edge Distribution (KE Method)



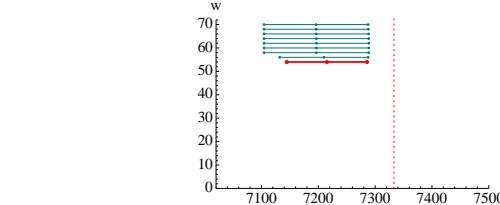
Peak Ranges (KE)



Edge Measurements (KE)

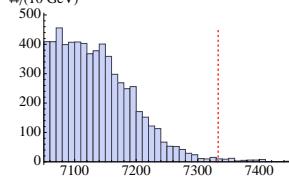


Overlapping Edge Measurements

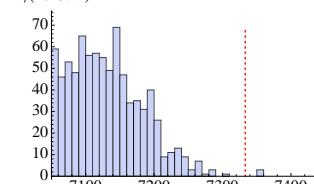


Edge Measurement: $7215 \pm 71 \text{ GeV}$ (Case A)

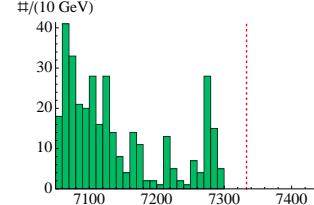
With Full Combinatorics Background
(8256 data points)



KE Method (1080 data points)



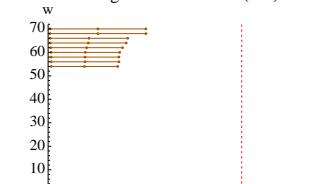
Edge Distribution (KE Method)



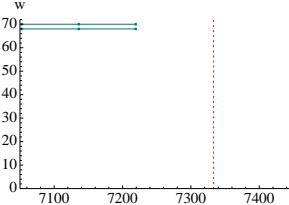
Peak Ranges (KE)



Edge Measurements (KE)



Overlapping Edge Measurements



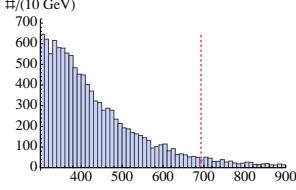
No Edge Measurement (Case D).

Figure 15: $M_{T2}^{210}(E_b)$ (Second Monte Carlo Study). Prediction: $M_{T2}^{max} = 7333.1 \text{ GeV}$.

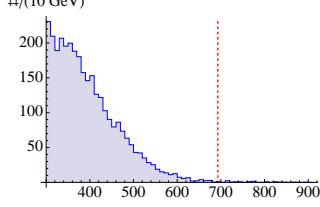
$M_{T2\perp}^{220}(0)$

$M_{T2}^{220}(0)$ with $p_{ISR}^T < 50$ GeV

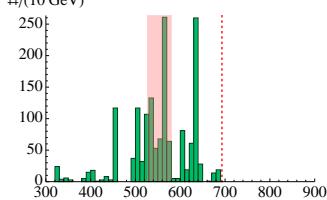
With Full Combinatorics Background
(28155 data points)



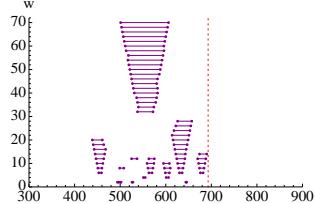
KE Method (3143.83 data points)



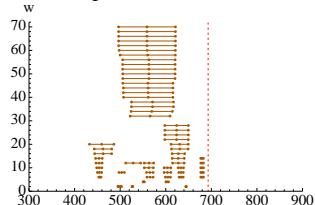
Edge Distribution (KE Method)



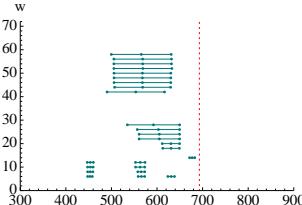
Peak Ranges (KE)



Edge Measurements (KE)

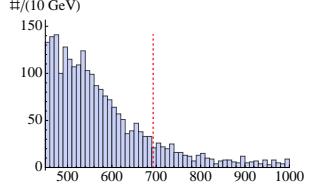


Overlapping Edge Measurements

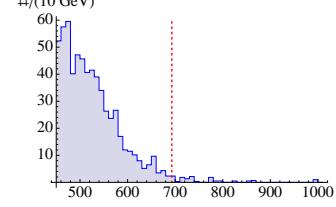


Edge Measurement: 598 ± 165 GeV (Case C)

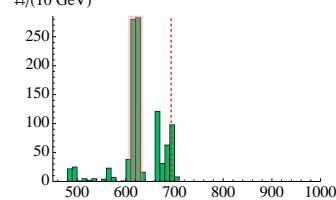
With Full Combinatorics Background
(4128 data points)



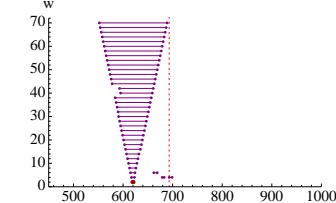
KE Method (638.167 data points)



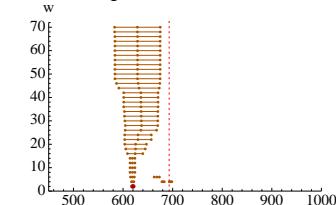
Edge Distribution (KE Method)



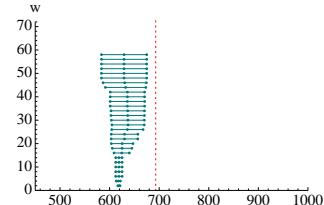
Peak Ranges (KE)



Edge Measurements (KE)



Overlapping Edge Measurements



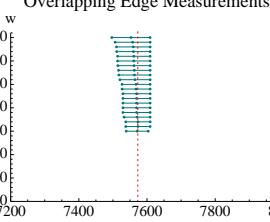
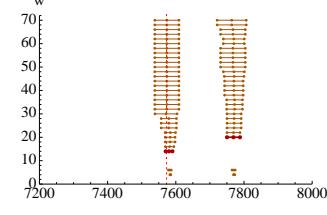
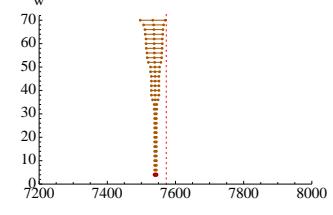
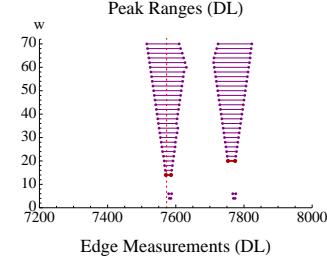
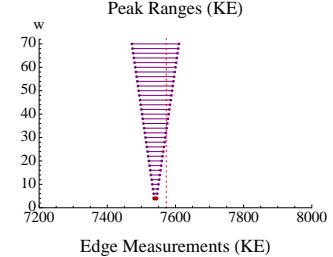
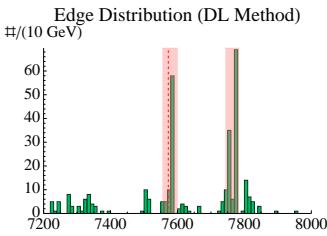
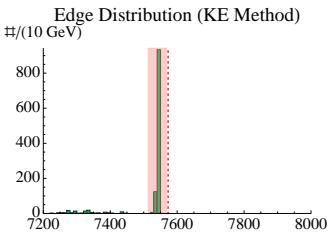
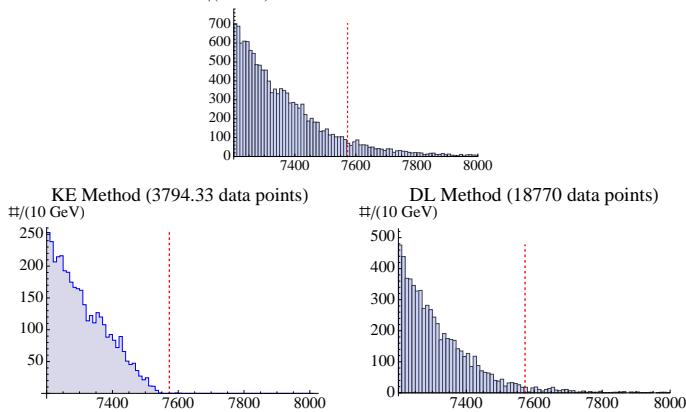
Edge Measurement: 681 ± 64 GeV (Case B)

Figure 16: $M_{T2}^{220}(0)$ (Second Monte Carlo Study). Prediction: $M_{T2}^{max} = 693.0$ GeV.

$M_{T2\perp}^{220}(E_b)$

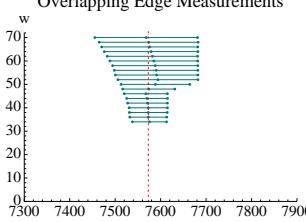
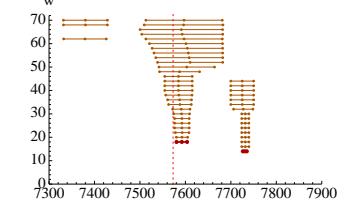
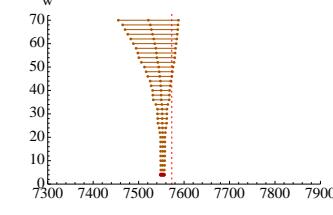
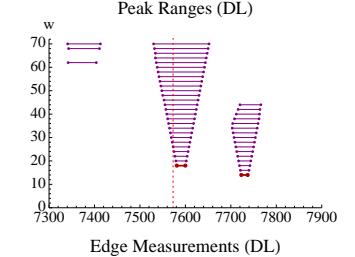
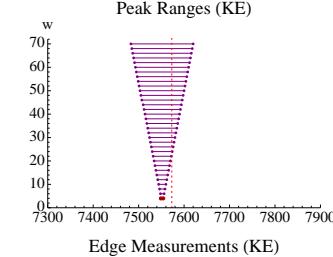
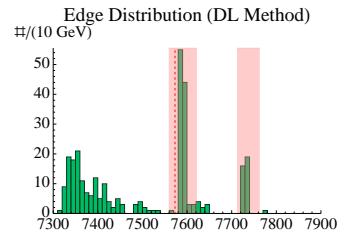
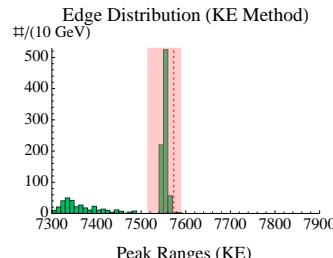
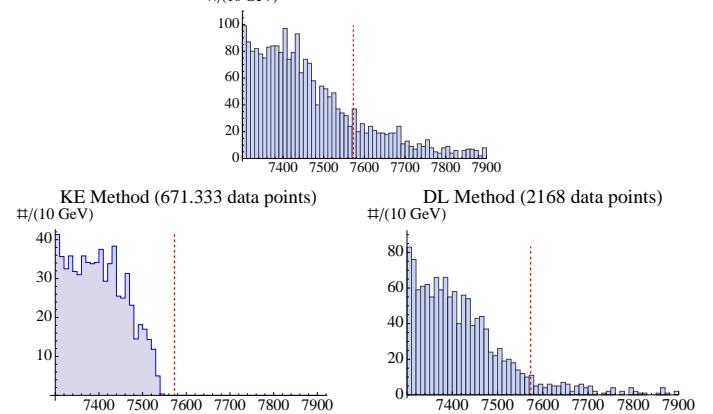
$M_{T2}^{220}(E_b)$ with $p_{ISR}^T < 40 \text{ GeV}$

With Full Combinatorics Background
(28155 data points)



Edge Measurement: $7663 \pm 125 \text{ GeV}$ (Case B)

With Full Combinatorics Background
(3252 data points)



Edge Measurement: $7642 \pm 93 \text{ GeV}$ (Case B)

Figure 17: $M_{T2}^{220}(E_b)$ (Second Monte Carlo Study). Prediction: $M_{T2}^{max} = 7572.9 \text{ GeV}$

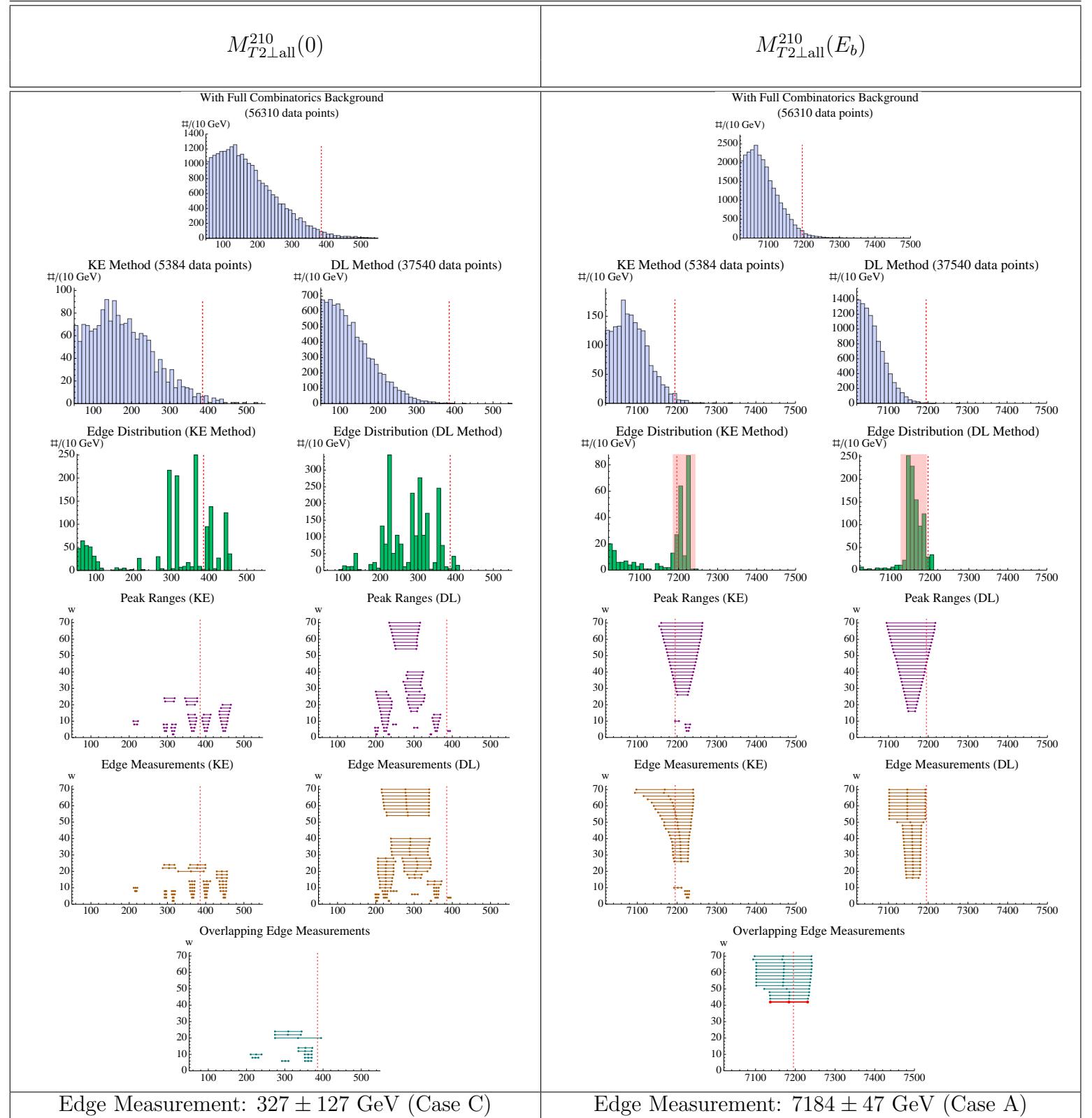


Figure 18: $M_{T2 \perp \text{all}}^{210}(0)$ and $M_{T2 \perp \text{all}}^{210}(E_b)$ (Second Monte Carlo Study). Predictions: $M_{T2}^{\max} = 385.5$ GeV and 7195.4 GeV respectively.